



**UNIVERSITI PUTRA MALAYSIA**

**OIL PALM AND NIPAH FROND SILAGES AND THEIR  
UTILIZATION BY SHEEP**

**SIDEIG ADAM ABDALLA**

**IB 2001 6**

**OIL PALM AND NIPAH FROND SILAGES AND THEIR  
UTILIZATION BY SHEEP**

**By**

**SIDEIG ADAM ABDALLA**

**Thesis Submitted in Fulfillment of the Requirement for the Degree of  
Doctor of Philosophy in the Institute of Bioscience  
Universiti Putra Malaysia**

**April 2001**



## **Dedication**

This thesis is dedicated to all members of my family, Particularly my wife Aisha Abuzaid and our youngest daughter, Amal and all the others who showed every sort of endurance, patience and understanding during all stages of the study.

Abstract of the thesis submitted to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the Degree of Doctor of Philosophy

## **OIL PALM AND NIPAH FROND SILAGES AND THEIR UTILIZATION BY SHEEP**

By

**SIDEIG ADAM ABDALLA**

**April 2001**

**Chairperson: Associate Professor Dr. Norhani Bint Abdullah**

**Faculty: Institute of Bioscience**

A series of experiments was conducted to study the quality of silages made from oil palm (*Elaeis guineensis*) (OPF) and nipah fronds (*Nypa fruticans*) (NF) and to see the effects of adding molasses or urea on the silages. The results showed that fresh OPF had significantly ( $P < 0.05$ ) higher dry matter (DM), ether extractives (EE) and neutral detergent fiber (NDF) than NF. The non-structural carbohydrates (NSC), ash, lignin and tannin of OPF were significantly ( $P < 0.05$ ) lower than those of NF. The crude protein (CP), pH and lactic acid of the fresh OPF and NF were similar, but the buffering capacity (BC) of the fresh OPF was significantly ( $P < 0.05$ ) lower than NF.

Anatomical investigations showed that the two types of fronds were different in their structures. In OPF, the hypodermic layer consisted of two layers of thin walled

cells, while in NF the outermost layer of the hypodermis was made up of thick walled cells. In addition, lignified palisade cells were present below the epidermis of NF, but were absent in OPF.

The pH of ensiled OPF was significantly ( $P<0.01$ ) lower while the lactic acid higher than that of NF. Ensiled OPF had higher ( $P<0.01$ ) BC at day 30 of ensilage than that of NF. The addition of 10% molasses increased lactic acid content of OPF but not of NF, while 3% urea added singly or with 10% molasses did not improve the ensilability of both OPF and NF. However, 30% molasses increased the lactic acid of NF from 14.2 to 50.4 g/kg DM and lowered its pH from 4.7 to 4.0 at day 30.

Digestibility studies *in situ* in sheep showed that the potential degradability of both untreated or molasses treated OPF were significantly ( $P<0.01$ ) higher than that of NF. The rumen ammonia nitrogen concentration of sheep fed OPF silage was significantly higher than sheep fed NF silage.

In the feeding trial conducted for 63 days, lambs fed molasses treated NF silage showed significantly ( $P<0.05$ ) higher silage intake as well as live weight gain (LWG) than lambs fed untreated NF silage. Similarly, lambs fed molasses treated OPF silage showed higher silage intake and LWG than lambs fed untreated OPF. A regression equation to show the relationship between % potential degradability ( $a + b$ ) and voluntary feed intake (VFI) in g/kg  $W^{0.75}$  was  $0.5(a + b) + 51.5$ , ( $r^2 = 0.65$ ).

**SILAJ PELEPAH KELAPA SAWIT DAN NIPAH DAN PENGGUNAANNYA  
SEBAGAI MAKANAN TERNAKAN BIRI-BIRI**

Oleh

**SIDIEG ADAM ABDALLA**

**April 2001**

**Pengerusi: Profesor Madya Dr. Norhani Bint Abdullah**

**Fakulti: Institut Biosains**

Satu siri eksperimen telah dijalankan untuk mengkaji kualiti silaj yang dihasilkan daripada pelepah kelapa sawit (*Elaeis guineensis*)(OPF) dan pelepah nipah (*Nypa fruticans*)(NF) serta kesan penambahan molases atau urea ke atas silaj. Pengambilan OPF dan NF dilakukan sebanyak tiga kali daripada ladang berhampiran semasa kajian dijalankan. Hasil kajian mendapati OPF segar mengandungi DM, EF dan NDF yang lebih banyak ( $P < 0.05$ ) berbanding NF, tetapi NSC, abu, lignin dan tannin OPF adalah kurang ( $P < 0.05$ ) dari NF. Kandungan CP OPF segar and NF adalah sama begitu juga nilai pH dan asid laktik tetapi BC OPF segar adalah lebih tinggi ( $P < 0.05$ ) dari NF.

Kajian anatomi menunjukkan kedua-dua jenis pelepah mempunyai struktur yang berbeza. OPF mempunyai lapisan hipodermis yang terdiri daripada dua lapisan sel berdinding tebal. Manakala, sel palisad yang berlignin di dapati di bahagian bawah epidermis NF dan sel tersebut tidak di dapati pada OPF.

Nilai pH silaj OPF adalah lebih rendah ( $P < 0.01$ ) manakala kandungan asid laktik silaj OPF lebih tinggi berbanding NF. Silaj OPF mempunyai nilai BC yang lebih tinggi ( $P < 0.01$ ) pada hari ke 30 berbanding nilai BC silaj NF. Penambahan 10% molases meningkatkan kandungan asid laktik OPF manakala penambahan 3% urea secara berasingan atau bersama 10% molases, tidak berkesan terhadap kedua-dua OPF dan NF. Walaubagaimanapun, 30% molases meningkatkan asid laktik NF daripada 14.2 kepada 50.4 g/kg DM serta merendahkan pH daripada 4.7 ke 4.0 pada hari ke 30.

Kajian penghadaman *in situ* bebiri menunjukkan potensi degradibiliti kedua-dua OPF yang tidak di rawat dan di rawat dengan molases adalah lebih tinggi ( $P < 0.01$ ) berbanding NF. Kepekatan ammonia nitrogen rumen bebiri yang di beri silaj OPF adalah juga lebih tinggi berbanding bebiri yang di beri NF.

Dalam kajian pemakanan yang dijalankan selama 63 hari, anak bebiri yang diberi NF yang di rawat dengan molases menunjukkan peningkatan pengambilan makanan dan LWG yang signifikan ( $P < 0.01$ ). Keputusan yang sama juga diperolehi pada anak bebiri yang diberi silaj OPF yang di rawat dengan molases di mana terdapatnya peningkatan pengambilan makanan dan LWG.

Persamaan regresi untuk menunjukkan kaitan antara potensi degradibiliti ( $a + b$ ) dan pengambilan makanan (VFI) g/kg  $W^{0.75}$  ialah  $0.50(a + b) + 51.5$  ( $r^2 = 0.5$ ).

## ACKNOWLEDGEMENTS

I wish to acknowledge the invaluable suggestions, discussion and guidance of the Chairman of my Supervisory Committee, Assoc. Prof. Dr. Norhani Abdullah, of the Department of Biochemistry and Microbiology, UPM. The financial support and academic assistances that I received during the course of my study are highly appreciated and sincerely accepted. I would also like to express my thanks and sincere gratitude to the other members of my supervisory committee, Prof. Dr. Ho Yin Wan, the Deputy Director of Institute of Bioscience and to Assoc. Prof. Dr. Liang Juan Boo, the coordinator of the Animal Nutrition Laboratory, UPM and to Mr. Shamsudin Abu Bakar of MARDI who is an advisor to my research project. I will always remember their sincere patience, effective guidance, fruitful discussion and supervision during the various stages of my study.

The encouragement and kind help offered by Professor Tan Sri, Dr. Syed Jalaludin Syed Salim, the Senior Member of the Digestive Microbiology Laboratory and Vice Chancellor of UPM, are deeply appreciated. Thanks are also due to Assoc. Prof. Dr. Zainal Aznam Jelani, Head of the Department of Animal Science, UPM for his help and to Dr Ridzwan A. Halim, Faculty of Agriculture for his help and advices on statistical analyses. My thanks are also extended to Assoc. Prof. Dr. Abdul Razak Alimon, Mr. Ibrahim bin Mohsin, Mr. Sabarin bin Demin and Mr. Bakari bin Abd. Rahman for their help.



I wish also to acknowledge the discussion and suggestions given by Dr. E.R. Ørskov from Rowette Research Institute, Aberdeen, UK. The useful discussion with Dr. K.K. Bolsen is also sincerely appreciated.

Appreciation is extended to all the staff of the Institute of Bioscience, particularly Mr. Khairul Kamar Bakri, Madame Haw Ah Kam, Mr. Jivanan Arumugam and Miss Suleka Madahavan. Sincere appreciation is also extended to Dr. Lokman, Dr. Siti Nur and other staff of the Veterinary Hospital, UPM, for their help in fistulating the sheep. Efforts and assistance of Mr. Nagayah Muniandy and Mr. Paimon Lugiman for caring the animals were highly appreciated. My gratitude and thanks are also due to Mr. Yunus and other members of the Silage Unit in MARDI. Sincere gratitude is also expressed to all my colleagues in both the Digestive Microbiology laboratory and the Animal Nutrition Laboratory for their help and suggestions. I greatly appreciate the help and co-operation given by all the Malaysian Government Departments during the course of my study.

Finally, I wish to thank the Faculty of Veterinary Science, University of Nyala and the Ministry of High Education of the Sudan for the grant and study leave, and to Universiti Putra Malaysia for the fellowship to pursue my Ph. D degree.



I certify that an Examination Committee met on 14<sup>th</sup> April 2001 to conduct the final examination of Sideig Adam Abdalla on his Doctor of Philosophy thesis entitled “Oil Palm and Nipah Frond Silages and Their Utilization by Sheep” in accordance with Universiti Pertanian Malaysia (High Degree) Act 1980 and Universiti Pertanian Malaysia (High Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

Dr. Abd Razak Alimon, Ph. D,  
Associate Professor,  
Faculty of Agriculture,  
Universiti Putra Malaysia,  
(Chairman)

Dr. Norhani Bint Abdullah, Ph. D,  
Associate Professor,  
Faculty of Science and Environmental Studies,  
Universiti Putra Malaysia,  
(Member)

Dr. W.Y. Ho, Ph. D,  
Professor,  
Institute of Bioscience,  
Universiti Putra Malaysia,  
(Member)

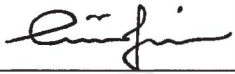
Dr. J. B. Liang, Ph. D,  
Assoc. Prof.,  
Faculty of Agriculture,  
Universiti Putra Malaysia,  
(Member)



**MOHD. GHAZALI MOHAYIDIN, Ph. D,**  
Professor/ Deputy Dean of Graduate School,  
Universiti Putra Malaysia

Date: 02 MAY 2001

This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of the requirement of the degree of Doctor of Philosophy.



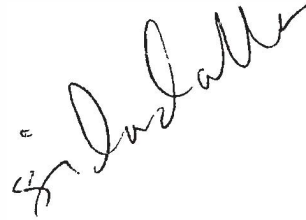
---

**AINI IDERIS, Ph. D,**  
Professor,  
Dean of Graduate School,  
Universiti Putra Malaysia

Date:

## DECLARATION

I hereby declare that this thesis is based on my original work except for quotations and citations, which have duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.



Sideig Adam Abdalla,

2001

## TABLE OF CONTENTS

	Page
DEDICATION.....	ii
ABSTRACT.....	iii
ABSTRAK.....	v
ACKNOWLEDGEMENTS.....	vii
APPROVAL SHEETS .....	ix
DECLARATION FORM.....	xi
LIST OF TABLES.....	xvi
LIST OF FIGURES.....	xxiii
LIST OF ABBREVIATIONS.....	xxvi

## CHAPTER

I	INTRODUCTION.....	1
II	LITERATURE REVIEW.....	4
	Silage Fermentation.....	4
	Historical Background.....	4
	Microbial Activity during Silage Fermentation .....	5
	Causes and Extent of Losses during Ensilage .....	7
	The Significance of Lactic Acid for Ensilage .....	9
	The Use of Molasses in Silage Production .....	11
	Factors Determining Proper Ensilage .....	12
	Internal Factors.....	13
	External Factors .....	20
	Relationship between Plant Chemistry and Silage Production .....	23
	Utilization of Silage by Animals .....	24
	Degradation Parameters as a Measure of Nutrient Value of Feed .....	25
	Feed Intake as a Measure of Feed Quality .....	26
	Intake of Silage.....	28
	Effect of Silage Proteins and Other Nitrogenous Compounds on VFI .....	30
	Prediction of Intake Using Chemical Constituents of the Feed .....	31
III	CHEMICAL COMPOSITION AND ANATOMICAL CHARACTERISTICS OF OIL PALM (OPF) AND NIPAH FRONDS (NF) IN RELATION TO ENSILAGE .....	33



	Page
Material and Methods.....	34
The Fronds.....	34
The Silo and Ensiling Techniques .....	35
Sampling and Analytical Techniques.....	35
Anatomical Investigations.....	45
Statistical Analysis.....	45
Results.....	46
Temperature, pHs and Chemical Characteristics of the Fresh OPF and NF.....	46
Anatomical Structures of the Fresh OPF and NF	49
Factorial Analysis of the Ensiled OPF and NF.....	55
Characteristics of OPF and NF at 15 Days of Ensilage	60
Temperature, pHs and Chemical Characteristics of the Fronds at 30 Days of Ensilage .....	64
Temperature, pHs and Chemical Characteristics of OPF and NF at 60 and 90 Days of Ensilage.....	66
Changes in Temperature and pHs of OPF and NF at Different Ensiling Periods.....	68
Changes in Chemical Composition of OPF and NF at Different Ensiling Periods.....	69
Changes in SS Contents of OPF and NF at Different Ensiling Periods.....	74
Discussion .....	75
Characteristics of the Fresh OPF and NF .....	75
Characteristics of the Fermented OPF and NF Silages.....	77
The Quality of the OPF and NF Silages.....	81
Possible Causes of Poor Ensilability of NF.....	82
 IV      EFFECTS OF TREATMENT OF OIL PALM AND NIPAH FRONDS WITH MOLASSES AND UREA DURING ENSILAGE	85
Introduction.....	85
Materials and Methods .....	86
Experiment 1 .....	86
Experiment 2.....	87
pH Determination .....	88
Analytical Techniques: .....	88
Statistical Analysis .....	90
Results of Experiment 1 .....	91
Chemical Characteristics of Fresh Untreated and Treated OPF and NF (Day 0) .....	96
Effects of Ensiling on Untreated OPF and NF at Day 15	99

	Page
Effects of Molasses on OPF and NF Silages at Day 15.....	102
Effects of Urea on OPF and NF Silages at Day 15.....	104
Effects of Molasses and Urea (M + U) on OPF and NF Silages at Day 15 .....	106
Effects of Ensiling on the Untreated (Control) OPF and NF at Day 30 .....	109
Effects of Molasses on OPF and NF Silages at Day 30....	112
Effects of Urea on OPF and NF Silages at Day 30.....	114
Effects of Molasses and Urea (M + U) on OPF and NF Silages at Day 30.....	116
Effects of Ensiling on the Untreated and Treated OPF and NF at Days 60 and 90.....	118
Changes in Lactic Acid Concentration during Ensiling...	127
Results of Experiment 2 .....	129
pH and Chemical Characteristics of OPF and NF at Day 0	129
pH and Chemical Characteristics of OPF and NF at Day 15.....	133
pH and Chemical Characteristics of Molasses Treated NF Silage at day 15.....	135
pH and Chemical Characteristics of Untreated OPF and NF Silages at Day 30.....	136
pH and Chemical Characteristics of Molasses treated NF Silage at Day 30.....	136
pH and Chemical Characteristics of Untreated OPF and NF Silages at Day 60.....	139
pH and Chemical Characteristics of Molasses Treated NF Silage at Day 60 .....	140
Changes in Lactic Acid Concentration and Buffering Capacity Values of OPF and NF during Ensilage.....	141
Discussion.....	142
 V     DEGRADATION CHARACTERISTICS OF FROND SILAGES AND RUMEN FERMENTATION ....	147
Introduction.....	147
Materials and Methods.....	148
Degradability Studies of Silages in Sheep Fed Fresh Grass as the Basal Diet.....	148
Degradability Studies in Sheep Fed Frond Silages as the Basal Diet .....	150
Chemical Analysis of the Silages and Incubated Samples...	151
Preparation of Rumen Liquor for VFA and Ammonia N Analyses .....	151

	<b>Page</b>
Determination of VFA .....	152
Determination of Ammonia Nitrogen.....	153
Statistical Analyses.....	154
Results .....	154
Chemical Composition of the Silages and Concentrate... ..	154
Degradation Characteristics of Silage in Sheep Fed Grass	159
Degradation of the Organic Matter.....	164
Degradation of the Neutral Detergent Fiber.....	167
Degradation of Acid Detergent Fiber .....	170
Degradation of Lignin .....	172
Degradation Characteristics of Silage in Sheep Fed	
Fronds Silage .....	176
Rumen Fluid Characteristics .....	180
Discussion .....	192
 VI     INTAKE AND PERFORMANCE OF LAMBS FED	
FROND SILAGES .....	199
Introduction.....	199
Materials and Methods .....	201
<i>In vivo</i> Digestibility Trials .....	202
Chemical Analyses.....	202
Regression Analysis for the Prediction of Intake .....	203
Statistical Analysis of Data .....	203
Results .....	204
Animal Performance .....	204
<i>In vivo</i> digestibility.....	210
Prediction of Intake.....	214
Discussion .....	218
 VII    GENERAL DISCUSSION AND CONCLUSIONS.....	226
 BIBLIOGRAPHY.....	237
 APPENDICES.....	254
 BIOGRAPHICAL VITA .....	264



## LIST OF TABLES

Table	Page
3.1    Temperatures, pHs, Lactic Acid and Buffering Capacity (BC) Values of Oil Palm Fronds (OPF) and Nipah Fronds (NF) at Day 0.....	46
3.2    Chemical Compositions of Fresh (Day 0) Oil Palm Fronds (OPF) and Nipah Fronds (NF). ....	47
3.3    Comparisons between OPF and NF in Temperature ( $^{\circ}\text{C}$ ), pH, Lactic acid (g/kg DM) and Buffering Capacity (m-equ/100g) and the Mean Squares and F Values of Several Influencing Factors, Including Two Frond Types and 15 Time Periods..	56
3.4    Comparisons Between OPF and NF in Percentages of Dry Matter, Ash and Organic Matter and their Analysis of Variance Showing Mean Squares and F Values of Several Influencing Factors, Including Two Frond Types and 15 Time Periods.....	57
3.5    Comparisons Between OPF and NF in their Percentages of Crude Protein, Ether Extractives and Neutral Detergent Fiber and their Analysis of Variance Showing the Mean Squares and F Values of Several Influencing Factors, Including Two Frond Types and 15 Different Time Periods.....	58
3.6    Comparisons Between OPF and NF in their Percentages of Acid Detergent Fiber, Lignin, Non Structural Carbohydrates, and Soluble Sugars and their Analysis of Variance Showing the Mean Squares and F Values of Several Influencing Factors, Including Two Frond Types and 15 Different Time Periods.....	59
3.7    Temperatures, pHs and Chemical Characteristics of Oil Palm Fonds (OPF) and Nipah Fronds (NF) at 15 Days of Ensilage.....	61
3.8    Changes in Buffering Capacity (BC) Values of Oil Palm Fronds (OPF) and Nipah Fronds (NF) during the First Two Weeks of Ensilage. ....	63
3.9    Temperatures, pHs and Chemical Chacteristics of Oil Palm (OPF) and Nipah Fronds (NF) at 30 Days of Ensilage.....	65
3.10    Temperatures, pHs and Chemical Characteristics of Oil Palm (OPF) and Nipah Fronds (NF) at 60 and 90 Days of Ensilage. ...	67

	<b>Page</b>
4.1 The pH and the Percentage Values of DM and Ash of OPF and NF and their Analysis of Variance (ANOVA) Showing the Mean Squares and F Values of Several Factors Including Two Frond Types, Four Different Treatments and Five Time Periods and their Interactions.....	92
4.2 The Percentage Values of Crude Protein, Ether Extractives and Neutral Detergent Fiber of OPF and NF and their Analysis of Variance (ANOVA) Showing the Mean Squares and F Values of Several Factors Including Two Frond Types, Four Different Treatments and Five Time Periods and their Interactions .....	93
4.3 The Percentage Values of Acid Detergent Fiber, Soluble Sugars and Lignin of OPF and NF and their Analysis of Variance (ANOVA) Showing Mean Squares and F Values of Several Factors Including Two Frond Types Four Different Treatments and Five Time Periods and their Interactions.....	94
4.4 The Mean Values of Lactic Acid and Buffering Capacity of OPF and NF and their Analysis of Variance Showing the Mean Squares and F Values of Several Factors Including Two Frond Types, Four Different Treatments and Five Different Time Periods and their Interactions.....	95
4.5 pH and Chemical Characteristics of Untreated or Treated Oil Palm Fronds (OPF) and Nipah Fronds (NF) at Day 0 of Ensilage.....	97
4.6 Effects of Treatment of OPF and NF with Molasses (M) and Urea (U) on their pH and Chemical Compositions at Day 0.....	98
4.7 pH and Chemical Characteristics of Untreated or Treated Oil Palm Fronds (OPF) and Nipah Fronds (NF) at Day 15. ....	100
4.8 Effects of Molasses (M) and Urea (U) Treatments on the Silage Characteristics of OPF and NF at Day 15.....	103
4.9 pH and Chemical Characteristics of Untreated or Treated Oil Palm Fronds (OPF) and Nipah Fronds (NF) Ensiled at Day 30.....	110
4.10 Effects of Molasses (M) and Urea (U) Treatments on the Silage Characteristics of OPF and NF at Day 30.....	111

	<b>Page</b>
4.11 pH and Chemical Characteristics of Untreated or Treated Oil Palm (OPF) and Nipah Fronds (NF) Ensiled at Day 60. ....	119
4.12 pH and Chemical Characteristics of Untreated or Treated Oil Palm (OPF) and Nipah Fronds (NF) Ensiled at Day 90.....	120
4.13 Effects of Molasses (M) and Urea (U) Treatments on the Silage Characteristics of OPF and NF at Day 60.....	121
4.14 Effects of Molasses (M) and Urea (U) Treatments on the Silage Characteristics of OPF and NF at Day 90.....	122
4.15 Mean Percentage Values of pH, Dry Matter and Ash of OPF and NF and the Analysis of Variance Showing Mean Squares and F Values of Several Factors Including Two Frond Types, Four Different Treatments and Five Time Periods.....	130
4.16 Mean Percentage Values of Crude Protein, Neutral Detergent Fiber and Lignin of OPF and NF and the Analysis of Variance (ANOVA) Showing Mean Squares and F Values of Several Factors Including Two Frond Types, Four Different Treatments and Five Time Periods.....	131
4.17 Mean Percentage Values of Lactic Acid and Buffering Capacity of OPF and NF and the Analysis of Variance (ANOVA) Showing Mean Squares and F Values of Several Factors Including Two Frond Types, Four Different Treatments and Five Time Periods....	132
4.18 pH and Chemical Characteristics of Fresh Oil Palm (OPF) and Nipah Fronds (NF) at Day 0.....	133
4.19 pH and Chemical Characteristics of Untreated Oil Palm (OPF) and Nipah Frond (NF) silages at Day 15.....	134
4.20 pH and Chemical Characteristics of Untreated Nipah Fronds (NF-0) or NF Treated with Molasses at the Rate of 10, 20 and 30% of Fronds DM (NF-10, NF-20, and NF-30, Respectively) at 15 Days of Ensilage.....	135
4.21 pH and Chemical Characteristics of Untreated Oil Palm (OPF) and Nipah Frond (NF) Silages at Day 30.....	137

	<b>Page</b>
4.22 pH and Chemical Characteristics of Untreated Nipah Fronds (NF-0) or NF Treated with Molasses at the Rate of 10, 20 and 30% of Fronds DM (NF-10, NF-20, and NF-30, Respectively) at 30 Days of Ensilage.	138
4.23 pH and Chemical Characteristics of Untreated Oil Palm (OPF) and Nipah Fronds (NF) Silages at Day 60.....	139
4.24 pH and Chemical Characteristics of Untreated Nipah Fronds (NF-0) or NF Treated with Molasses at the Rate of 10, 20 and 30% of Fronds DM (NF-10, NF-20, and NF-30, Respectively) at 60 Days of Ensilage.....	140
5.1 The Percentage Values of Dry Matter, Ash and Crude Protein in OPF and NF and the Analysis of Variance of the Different Parameters when Untreated or Molasses Treated Frond Silages were Incubated in the Rumen of Sheep Fed Grass and Concentrate Pellets.....	156
5.2 The Percentage Values of Ether Extract, Neutral Detergent Fiber and Lignin in OPF and NF and the Analysis of Variance of the Different Parameters when Untreated or Molasses Treated Frond Silages were Incubated in the Rumen of Sheep Fed Grass and Concentrate Pellets.....	157
5.3 Percentage of Dry Matter and the Chemical Composition of Oil Palm and Nipah Frond (OPF, NF) Silages Untreated (0) or Treated with 30% Molasses (30) and the Composition of Concentrate Supplement (Conc.) in DM Basis.....	158
5.4 Percentage Degradability of Dry Matter, Organic Matter and Neutral Detergent Fiber of OPF and NF and Analysis of Variance of the Different Parameters when Untreated or Molasses Treated Frond Silages were Incubated in the Rumen of Sheep Fed Grass and Concentrate Pellets.....	160
5.5 Percentage Values of the Degradation of Acid Detergent Fibre and Lignin of OPF and NF and Analysis of Variance of the Different Parameters when Untreated or Molasses Treated Frond Silages were Incubated in the Rumen of Sheep Fed Grass and Concentrate Pellets.....	161

	<b>Page</b>
5.6 Percentages of Dry Matter Losses of Oil Palm and Nipah Frond Silages Untreated (0) or Treated with 30% Molasses (30) Incubated for Different Periods in the Rumen of Sheep Fed Fresh Grass and Concentrate Pellets.....	162
5.7 Percentages of Organic Matter Losses of Oil Palm and Nipah Frond Silages Untreated (0) or Treated with 30% Molasses (30) Incubated for Different Periods in the Rumen of Sheep Fed Fresh Grass and Concentrate Pellets.....	165
5.8 Percentage Losses of the Neutral Detergent Fiber (NDF) of Oil Palm and Nipah Frond Silages Untreated (0) or Treated with 30% Molasses (30) Incubated in the Rumen of Sheep Fed Fresh Grass and Concentrate Pellets.....	168
5.9 Percentage Losses of Acid Detergent Fiber (ADF) of Oil Palm and Nipah Frond Silages Untreated (0) or Treated with 30% Molasses (30) Incubated in the Rumen of Sheep Fed Fresh Grass and Concentrate Pellets.....	171
5.10 Percentage Losses of Lignin of Oil Palm and Nipah Frond Silages Untreated (0) or Treated with 30% Molasses (30) when Incubated in The Rumen of Sheep Fed Fresh Grass and Concentrate Pellets...	173
5.11 The Mean Values of DM Degradability of OPF and NF and their Analysis of Variance Showing the Mean Squares and F Values of Several Factors, Including Two Frond Types, Two Different Treatments and Six Different Time Periods and their Interactions...	177
5.12 Percentages of DM Losses at Different Incubation Times, the Degradation Constants of Oil Palm and Nipah Frond Silages and the Effect of Molasses Treatment on the Fronds Incubated in the Rumen of Sheep Fed the Respective Type of Silage Supplemented with Concentrate Pellets. ....	178
5.13 The Mean Values of pH, Buffcring Capacity and Ammonia Concentrations of Sheep Fed OPF and NF and their Analysis of Variance Showing the Mean Squares and F Values of Several Factors Including Two Frond Types, Two Different Treatments and Five Different Time Periods and their Interactions.....	181

	<b>Page</b>
5.14 pH Values of Rumen Samples Collected at Different Periods from Sheep Fed Untreated (0) or 30% Molasses Treated Silage (30) of Oil Palm Fronds (OPF) and Nipah Fronds (NF) Supplemented with Concentrate Pellets.....	182
5.15 Buffering Capacity (BC) in Milli-equivalents per 15 g Rumen Liquor (RL) Collected at Different Periods from the Rumen of Sheep Fed Silage of Untreated or 30% Molasses Treated Fronds of Oil Palm or Nipah Fronds and Concentrate Pellets.....	183
5.16 The Mean Values of Acetic, Propionic and Butyric Acids of Sheep Fed OPF and NF and their Analysis of Variance Showing the Mean Squares and F Values of Several Factors Including Two Frond Types, Two Different Treatments and Five Different Time Periods and their Interactions.....	186
5.17 The Percentage Mean Values of Iso-butyric and Iso-valeric Acids of Sheep Fed OPF and NF and their Analysis of Variance Showing the Mean Squares and F Values of Several Factors Including Two Frond Types, Two Different Treatments and Five Different Time Periods and their Interactions.....	187
5.18 Total and Individual Concentrations (mM/l) of Volatile Fatty Acids (VFA) and the Percentage Values of Individual Acids in the Rumen of Sheep Fed Untreated (0) or 30% Molasses Treated (30) Oil Palm and Nipah Frond Silages and Concentrate Pellets...	188
5.19 Ammonia N Concentrations (mg/l) of Rumen Samples Collected at Different Intervals from the Rumen of Sheep Fed Silages of Oil Palm and Nipah Fronds Untreated or Treated with Molasses and Supplemented with Concentrate Pellets.....	191
6.1 Total Feed Intake of Rations, Intake per Day and Total Silage Intake by Malaysian Lambs Fed Oil Palm and Nipah Frond Silages with Concentrate Pellets during 63 Days of Experimental Period.....	206
6.2 Performance Data Including Daily Silage Intake, Total Gain and the Average Live Weight Gain per Day for Malaysian Lambs Fed Oil Palm and Nipah Frond Silages with Concentrate Pellets during 63 Days of Experimental Period.....	207

	Page
6.3 Performance of Growing Lambs Fed Oil Palm or Nipah Fronds Ensiled Untreated or Treated with 30% Molasses Offered <i>ad libitum</i> and Supplemented with Concentrate Pellets.....	209
6.4 Percentage of Dry Matter Digestibility and Organic Matter Digestibility of Oil Palm and Nipah Frond Silages with Concentrate Pellets Fed to Malaysian Lambs during 63 Days of Experimental Period.....	211
6.5 Digestibility Measurements of Growing Lambs Fed Oil Palm (OPF) or Nipah Fronds (NF) Ensiled Untreated or Treated with 30% Molasses Offered <i>ad libitum</i> and Supplemented with Concentrate Pellets.....	212
6.6 Percentage of Crude Protein Digestibility and Neutral detergent Fiber Digestibility of Oil Palm and Nipah Frond Silages with Concentrate Pellets Fed to Malaysian Lambs during 63 Days of Experimental Period.....	213
6.7 The Regression Equations, Correlation Coefficients ( $r^2$ ) and the Level of Significance of $r^2$ , when the Voluntary Feed Intake was Regressed on the Metabolic Weight ( $W^{0.75}$ ) of Lambs Fed Rations Containing Frond Silages Supplemented with Concentrate Pellets...	215



## LIST OF FIGURES

Figure		Page
3.1	Part of a Mature Oil Palm Frond.....	50
3.2	Part of a Mature Nipah Frond Showing Spines of the Abaxial Surface	50
3.3	A Transverse Section of the Lamina of Oil Palm Frond Showing Cuticle, Upper Epidermis, Upper Hypodermis, Mesophyll, Vascular Bundles, Lower Epidermis and Stoma.....	52
3.4a	A Transverse Section of Oil Palm Lamina Showing Cuticle, Upper Epidermis, Hypodermis, Mesophyll, and Vascular Bundles.....	52
3.4b	A Transverse Section of Oil Palm Lamina Showing Mesophyll, Vascular Bundles, Lower Hypodermis, Lower Epidermis and Stoma...	53
3.5	A Transverse Section of the Lamina of Nipah Frond Showing Cuticle, Upper Epidermis, Upper Hypodermis, Mesophyll, Palsade, Lower Epidermis, Stoma and Vascular Bundle .....	54
3.6	A Transverse Section of Nipah Frond Lamina Showing Cuticle, Upper Epidermis, Outer Hypodermis, Inner Hypodermis, Palsade and Vascular Bundles.....	55
3.7	Lactic Acid Concentrations Produced from Oil Palm Fronds (OPF) and Nipah Fronds (NF) during an Ensiling Period of Three Months....	62
3.8	The Buffering Capacity (BC) Values of Oil Palm Fronds (OPF) and Nipah Fronds (NF) during Three Months of Ensilage.....	63
3.9	Temperatures of Oil Palm Fronds (OPF) and Nipah Fronds (NF) during Three Months of Ensilage.....	68
3.10	The pH Values of Oil Palm Fronds (OPF) and Nipah Fronds (NF) during Three Months of Ensiling.....	69
3.11	Changes in DM Contents of Oil Palm Fronds (OPF) and Nipah Fronds (NF) at Different Days during Three Months of Ensilage.....	70
3.12	The Ash Contents of Oil Palm Fronds (OPF) and Nipah Fronds (NF) at Different Days during Three Month of Ensilage.....	71
3.13	The CP Contents of Oil Palm Pronds (OPF) and Nipah Nronds (NF) at Different Days during Three Months of Ensilage.....	71